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Does government expenditure reduce inequalities in infant mortality rates in low- and middle-income countries? A time-series, ecological analysis of 48 countries from 1993-2013.

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Abstract

Introduction

Inequalities in infant mortality rates (IMR) are rising in some Low and Middle-Income Countries (LMICs) and falling in others, but the explanation for these divergent trends is unclear. We investigate whether government expenditures and redistribution are associated with reductions in inequalities in IMR.

Methods

We estimated country-level fixed-effects panel regressions for 48 LMICs (142 country-observations). Slope and Relative Indices of Inequality in IMR (SII and RII) were calculated from Demographic and Health Surveys between 1993-2013. RII and SII were regressed on government expenditure (total, health, and non-health) and redistribution, controlling for GDP, private health expenditures, a democracy indicator, country fixed effects, and time.

Results

Mean SII and RII was 39.12 and 0.69. In multivariate models, a one percentage-point increase in total government expenditure (% of GDP) was associated with a decrease in SII of -2.468 (95% CIs: -4.190, -0.746) and RII of -0.026 (95% CIs: -0.048, -0.004). Lower inequalities were associated with higher non-health government expenditure, but not higher government health expenditure. Associations with inequalities were nonsignificant for GDP, government redistribution, and private health expenditure.

Discussion

Understanding how non-health government expenditure reduces inequalities in IMR, and why health expenditures may not, will accelerate progress towards the Sustainable Development Goals.

Introduction

Global child mortality (deaths under the age of five years) has fallen by a remarkable 53% since 1990, and has fallen in nearly all low and middle income countries (LMICs) (You et al., 2015). However, inequalities in child mortality rates within countries remain high. If these inequalities could be reduced and average child mortality rates in each country were reduced to the rate seen among the wealthiest 10% in that country, then it is estimated that 2.9 million child deaths would be averted (Amouzou et al., 2014). Child mortality rates amongst the richest quintile in some LMICs can even be lower than the rates for the poorest quintile in some High Income Countries (HICs), justifying an even greater focus on within-country inequalities. Therefore, the Countdown to 2015 Report and the UN Inter-agency Group for Child Mortality Estimation have highlighted inequalities in child mortality as a key priority for the Sustainable Development Goal era (Victora et al., 2016; You et al., 2015).

This study focuses on social inequalities in Infant Mortality Rates (IMR – deaths in the first year per 1000 live births). Infant mortality is responsible for 45% of all child deaths worldwide (Liu et al., 2016), and the IMR remains high in many countries, predominantly due to death during the neonatal period (the first 28 days of life). IMR is a valuable indicator for assessing the short-term impact of changes in the social determinants of health because of the social origins of the main causes of infant death (Conley and Springer, 2001; Sartorius and Sartorius, 2014). Mortality during infancy stems from two main causes. Firstly, it is caused by complications before, during, or just after pregnancy, which respond to basic antenatal, obstetric, and neonatal health care services. Secondly, infant mortality is caused by infectious diseases, primarily pneumonia, diarrhoeal diseases, and malaria. These are strongly determined by intermediate social factors such as malnutrition, access to water and sanitation infrastructure, fertility rates, and education levels.

It is only recently that repeated Demographic and Health Surveys (DHS) have made it possible to study inequalities in IMR in LMICs (Houweling and Kunst, 2010). Studies have since identified divergent trends in inequalities in IMR that varied by country. For example Wagstaff et al. (2014) found that, between 1990 and 2011, approximately half of the 41 countries surveyed by the DHS program had falling inequalities in IMR over time, whilst half had increasing inequalities.

Houweling and Kunst, based on the seminal work of Mosley and Chen, argue that variations in inequalities in IMR are driven by inequalities in the intermediate causes of IMR (for example, access to water and sanitation), which are in turn driven by structural inequalities in society - particularly income and wealth inequalities (Houweling and Kunst, 2010; Mosley and Chen, 1984). Based on their work, three theoretical policy levers can be proposed that governments could use to influence inequalities in IMR: redistribution to reduce the underlying income and wealth inequalities, non-health government expenditure to reduce inequalities in the intermediate causes, and health expenditure to reduce inequalities in health care utilisation (see Figure 1: Conceptual Framework).

Few studies have attempted to empirically explain why some countries have high inequalities and some have low inequalities in IMR. Most have focused on child mortality rather than infant mortality. The earliest studies focused on longitudinal studies in individual countries (see review by Houweling and Kunst, 2010). There are difficulties arising from these studies as the results are often not generalisable beyond the country of study, and spurious results may be identified due to confounding with time trends (Sogaard, 1992; Wagstaff, 1985). For example, any association found between health care expenditure and changes in health inequalities may in fact be due to long term secular trends, such as economic growth or expanding access to education, which are often overlooked in these studies. Two recent cross-sectional studies using DHS data found no evidence that either income inequality or health expenditures were associated with inequalities in neonatal and child mortality (Kruk et al., 2011; McKinnon et al., 2016). The cross-sectional nature of these studies, however, means they are vulnerable to bias from unobserved confounding between countries, and cannot elucidate changes within countries – two challenges this study attempts to overcome.

The limited evidence on the relationship between government health expenditure and inequalities in IMR may stem from the study designs employed, but also may be due to alternative pathways by which government expenditures impact on health inequalities. As suggested by researchers of inequalities in high-income countries, government spending outside of health care may be of critical importance to the health of the poorest social groups and therefore may be more important for reducing inequalities (Dahlgren and Whitehead, 2006). This was a core message of the WHO Commission on the Social Determinants of Health, and has recently re-emerged in LMICs as a key justification for social protection policies (Adato and Bassett, 2009; WHO, 2008). Furthermore, government expenditure on health may be influenced by many factors that either exacerbate or re-enforce existing health inequalities. For example, elite capture, where those with higher status influence resource allocation to their own benefit, may exist and may be particularly problematic in LMICs where weaker accountability mechanisms often operate. This could be envisioned as increased expenditures on specialist secondary care, which may be opposed to the health needs of the more deprived. Conversely, expenditure on non-health areas may be more impervious to elite capture if the actions are universal (e.g. sanitation systems) or targeted towards deprived populations (e.g. social protection programmes). None-the-less, the extent to which this may be the case rests on wider factors including accountability, power structures, and political priorities, and little research has been conducted in these areas. To our knowledge, the relative association of health and non-health government expenditures on health inequalities in LMICs has not been examined.

This study aims to assess the association between government expenditures and social inequalities in IMR in a panel of 48 LMICs from 1993-2013. We examine how total government expenditure, government expenditure on health and non-health areas, and government redistribution efforts are associated with IMR inequalities.

<Figure 1 here >

Methods

Study design

This analysis employs fixed-effects panel data regression methods. Panel data methods are appropriate for repeated measures over time for each country (Wooldridge, 2003). Countries are the unit of analysis. The study was approved by the Imperial College Research Ethics Committee (reference 16IC3663).

Data

The main sources of data for the analysis were Demographic Health Surveys (DHS) carried out by The DHS Programme from years 1993 to 2013[1]. DHS are internationally standardised surveys based on a nationally representative sample of households in LMICs. Respondents provide information on household wealth[2], alongside complete birth histories and deaths, and use of health services by women and children. We obtained country-level data on IMRs for each wealth quintile in each country from the WHO's Global Health Observatory (WHO, 2016). The WHO produces this data based on DHS datasets. We included all countries that had been surveyed at least twice between 1993 and 2013 to create an

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[1] https://dhsprogram.com/

[2] Detailed information on how the DHS Programme defines and measures their wealth index is available at https://dhsprogram.com/topics/wealth-index/. In summary, they state *"The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities… the wealth index places individual households on a continuous scale of relative wealth. DHS then separates all interviewed households into five wealth quintiles."*

unbalanced panel of 48 LMICs. Countries had been surveyed between 2 and 7 times during the period 1993-2013.

Gross Domestic Product (GDP) per capita, government expenditure and its division into government sectors (including health, education, and military expenditure) were extracted from the World Development Indicators (in constant 2011 US Dollars, adjusted for PPP)(World Bank, 2016). Each government expenditure variable was then re-calculated as a percentage of GDP to account for GDP growth, inflation over time, and population growth. Additionally, private health expenditures (as a % of GDP), out of pocket (OOP) private health expenditures (as a % of GDP), and the *Polity IV* index of democracy were extracted from the World Development Indicators database (World Bank, 2016). As an alternative indicator of the strength of a country's democracy, we also extracted from the Database of Political Institutions data on whether a country uses proportional representation in their elections (World Bank, 2015).

We extracted income inequality indicators from the *Standardized World Income Inequality Database* (SWIID). We selected income inequality before government redistribution (GINI market), and income inequality after government redistribution (GINI net) taking the mean of the SWIID multiple imputation results (Solt, 2016). The GINI is a commonly used measure of income inequality, and ranges from 0 (perfect equality) to 1 (perfect inequality).

For sensitivity analysis, we also obtained fertility rates (live births per reproductive age women), access to health services (a composite index of access to key reproductive, maternal and child health services), and malnutrition (% stunting amongst children under 3) for each wealth quintile from the DHS datasets (WHO, 2016). Access to water and sanitation services was not available by quintile, so mean access to water and sanitation was extracted from the World Development Indicators database (World Bank, 2016).

Dependent variables

The main outcome variables were the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII). These were calculated from the quintile specific IMRs obtained for each country for each year that the country was surveyed. The SII and RII are, respectively, absolute and relative indices of inequality, and they have been widely employed in similar studies (e.g. McKinnon et al., 2014a). The SII, an absolute measure of inequality, is produced by linearly regressing the IMR in each quintile on the rank of the quintiles, and represents the absolute difference in IMR between the top and the bottom of the wealth distribution. The RII is the SII divided by the mean IMR, and represents the relative difference in IMR between the top and bottom of the wealth distribution. These measures are superior to simple differences and ratios of the bottom and top quintile's IMR as they are informed by data from all quintiles. We used quintile-based measures of inequality rather than concentration indices because quintile-based IMR data is publicly available and quality controlled from the WHO's Global Health Observatory, and because these measures are recommended both in the WHO's inequality handbook and O'Donnell et al (2008) World Bank report on measuring inequalities(O'Donnell et al., 2008; World Health Organization, 2013). In addition, the RII and the concentration index are closely related and considered mathematically equivalent, and so we would therefore expect results for the concentration index to be roughly similar to those presented in this paper (Wagstaff et al., 1991). Both SIIs and RIIs of IMR are used as dependent variables in this study and, whilst both measure inequalities, the results from both are presented as they have different normative interpretations, and can, at times, go in different directions (Houweling et al., 2007; Wagstaff, 2015).

Independent variables

Based on our conceptual framework (Figure 1), the main variables of interest were government expenditure on health (as a percentage of GDP), non-health government expenditure (as a percentage of GDP), and government redistribution effort. Non-health government expenditure was calculated by subtracting government health expenditure from total government expenditure. For a sub-sample of countries with the data available, military and education expenditures were then also subtracted to produce government expenditure net of health, education, and military expenditure. Government redistribution was calculated as the difference between the market GINI coefficient and the net (after tax) GINI coefficient to capture the degree to which governments were intervening to redistribute income.

Covariates were employed when modelling the SII and RII of IMRs to both identify associations and control for potential confounders. We included potential confounders of the relationship between government expenditure and inequalities in IMR based on a review of the literature (Houweling and Kunst, 2010), theoretical considerations from our conceptual framework, and data availability. GDP per capita was included to capture changes in country income, and was logged because it was heavily skewed. Private OOP health expenditures were subtracted from total private health expenditures to produce non-OOP private health expenditures (as a percentage of GDP). Private OOP and private non-OOP health expenditure capture the level of pre-pooling within the health system, the extent to which individuals are exposed to healthcare costs, and the overall role the private system plays in the health system. Both were included in the model as they may impart differential impacts on health inequalities (Spaan et al., 2012).

A democracy indicator (*Polity IV*) was included in the model as it may influence factors such as elite capture and the degree to which government efforts are focused on the poor. It has also been found to be associated with lower infant mortality and higher life expectancy in high income countries (Mackenbach et al., 2013). There is, however, extensive debate regarding the extent to which democracy is indeed pro-poor and can reduce health inequalities (Ross, 2006). *Polity IV* is the standard indicator for democracy in political and social science research (Munck and Verkuilen, 2002). We used the *polity2* version of the indicator that was produced specifically for time series analysis as part of the

Polity IV project[3]. It varies from -10 (strongly authoritarian) to +10 (strongly democratic), based on assessments of the competitiveness and openness of political participation and executive recruitment, and constraints on the executive. We also used the democracy indicator to create a democracy dummy variable and stratify additional analysis. This additional analysis enabled us to explore whether the relationship between government expenditure and inequalities in IMR varies according to a country's average level of democracy over our study period. In our sample, Polity IV was distinctly bimodal, and so we specified countries as lower democracy (if their average Polity IV over time was between -10 and +4.9) and higher democracy (Polity IV of 5.0 or above). 5.0 was selected as the cut-off because it was the median value in our sample. As part of the sensitivity analysis, we also ran the analysis by stratifying the countries into those that use proportional representation in their elections and those that did not.

Intermediate variables

Our conceptual framework assumes that income inequality and government expenditures can influence inequalities in IMR at least partly due to changes in inequalities in key intermediate variables. We therefore created Slope Indices of Inequality for three available indicators from the WHO's Global Health Observatory, which are based on DHS data (WHO, 2016). These were calculated from each wealth quintile's fertility rates, access to health services, and an indicator of malnutrition (% stunting amongst children under 3). Access to Water

[3] http://www.systemicpeace.org/polity/polity4.htm

and Sanitation services was not available by quintile, and so instead mean access to Water and Sanitation was used. These intermediate factors above were not available for all countries and are also potentially on the pathway between government expenditure and inequalities in IMR. Therefore to preserve the sample size and to avoid over-controlling they were not included in the base model, but added one by one during model sensitivity analysis.

Regression models

Fixed-effects panel regression was employed as an appropriate method for modelling panel data. Longitudinal regression methods were necessary as data points of each country over time in a panel are likely to be highly correlated (violating the principles of linear regression). Fixed-effects model specifications were used to control for any unobserved country characteristics (unobserved heterogeneity) that are constant over time and may be associated with observed explanatory variables (Wooldridge, 2003). This, for example, includes climate, natural resources, ethnic diversity, and cultural factors. This avoids omitted variable biases from time-invariant factors that can plague cross-sectional ecological research (Conley and Springer, 2001). On the other hand, only associations from the changes *within* countries over time are estimated. In other words, any associations between countries (i.e. between general levels of inequalities in IMR and government expenditures across countries) are not estimated. A random-effects specification may have been more efficient, however, Hausman tests confirmed that the random-effects assumption was violated in our models (Hausman test: p=0.003 for our main SII model, and p=0.028 for the our main RII model). The use of fixed-effects specifications is also particularly advantageous for our research question because data on the determinants of inequalities in LMICs is limited, preventing us from fully pre-specifying a model with all confounders. Whilst there is the potential for omitted variable bias from time-variant factors, we control for time trends to reduce the risk of confounding by secular trends (such as improving health technologies) that previous time series research may have been susceptible to (Sogaard, 1992; Wagstaff, 1985). A linear time specification was preferred over year dummies because the trends were found to be generally linear, and to preserve degrees of freedom in our small dataset. Alternative time specifications were included in sensitivity analysis. Because IMR responds rapidly to changing circumstances we followed previous authors and did not include lagged specifications of our models (Conley and Springer, 2001). Data was analysed in Stata 14.1 (StataCorp, 2015).

Statistical analysis

Firstly, a descriptive overview of the dataset was produced. For the study period (1993-2013), the overall mean, overall standard deviation, and the between-country and within-country standard deviation of each variable were calculated. The mean annual within-country change in each variable was calculated with univariate fixed-effects longitudinal regressions between each variable and time (as a linear variable). For some countries, certain variables were not available and so only a subset of countries was used with the number of countries and observations used indicated.

Secondly, multivariate fixed-effects longitudinal regression was employed with both the SII and RII of IMR for 48 countries as dependent variables. These were used to examine the relationship between total government expenditure and inequalities in IMR. In addition to total government expenditure as a percentage of GDP, models were controlled for GDP per capita (Log), Democracy indicator (*Polity IV)*, Private non-OOP health expenditure as a percentage of GDP, Private OOP health expenditure as a percentage of GDP, country-level fixed-effects, and a linear time trend. Sequential addition of covariates was undertaken and presented to demonstrate model stability. The model specifications were:

1) $IMR\_SII_{it} = Gov\_expenditure_{it} + LogGDP_{it} + Democracy_{it} + Private\_health\_not\_OOP_{it} + Private\_health\_OOP_{it} + Country_i + t + \varepsilon_{it}$

2) $IMR\_RII_{it} = Gov\_expenditure_{it} + LogGDP_{it} + Democracy_{it} + Private\_health\_not\_OOP_{it} + Private\_health\_OOP_{it} + Country_i + t + \varepsilon_{it}$

Where: X_{it} = the value of variable X in country i for the year t; ε_{it} = is the idiosyncratic error term for country *i* in year *t* (not estimated).

Thirdly, five multivariate fixed-effects longitudinal regressions with the same specifications as above were employed with the IMR of each wealth quintile as the dependent variable. This was done to understand better the relationship between inequalities in IMR and total government expenditure. The model specifications were:

3) $IMR_{qit} = Gov\_expenditure_{it} + LogGDP_{it} + Democracy_{it} + Private\_health\_not\_OOP_{it} + Private\_health\_OOP_{it} + Country_i + t + \varepsilon_{it}$

Where: X_{it} = the value of variable X in country i for the year t; IMR_{qit} = the IMR for wealth quintile q in country i for year t; ε_{it} = is the idiosyncratic error term for country i in year t (not estimated);

Fourthly, to examine whether the relationship between total government expenditure was influenced by the democratic nature of a country, stratification of the fixed-effects longitudinal regression models 1 and 2 were undertaken. A dummy variable for democracy was employed - indicating whether a country had high or low average levels of democracy over the study period.

Fifthly, disaggregation of total government expenditure was undertaken to further explore the relationship with inequalities in IMR. Total government expenditure was disaggregated into: i) health and non-health areas; ii) health, education, and non-health/non-education areas; iii) health, education, military, and non-health/non-education/non-military areas. The main regression models 1 and 2 specified above were repeated, using disaggregated government expenditures as dependent variables. Due to missing observations in the expenditure disaggregation data, a sub-sample of countries was used in some of the analysis (number of observations for each analysis are shown in the results tables).

Lastly, the effect of government redistribution efforts was explored. The regressions on the SII and RII of IMR with total government expenditure (models

1 and 2) were repeated, with the introduction of the government redistribution efforts variable. Due to missing data, 22.4% of the observations were excluded. For comparability, the regression models on total government expenditure (without government redistribution efforts) were repeated with this sub-sample of observations.

All regression models employed cluster-robust standard errors to take into account the clustered nature of the data, and mitigate potential autocorrelation and heteroskedascity (Wooldridge, 2010) .

Sensitivity analyses

We conducted additional analyses to check the sensitivity of our findings. Firstly, all regression models were re-run with outliers removed - defined as those with absolute studentized residuals of two or more, and without observations with a high leverage. Secondly, alternative specifications of the models were explored to identify potentially spurious relationships. The Stata module *mrobust* was employed to see if the results on total government expenditure were sensitive to inclusion or exclusion of variables (Young and Holsteen, 2015). Thirdly, the regression models were repeated with year dummies rather than a linear time trend. Fourthly, multivariate longitudinal models with total government expenditure were estimated with the additional intermediate variables included as covariates (specifically mean access to water and sanitation, and inequalities in fertility, stunting and health service access). Due to missing observations, the sample sizes for these models were considerably smaller and thus sequential addition of covariates was undertaken to preserve statistical power. Fifthly, we replaced government redistribution with income inequality before government redistribution (market GINI), and repeated the democracy stratification analysis, this time stratifying the countries into those that use proportional representation in their elections and those that did not. Finally, the absolute level of IMR was added to the main models to observe if the relationship between government expenditure and inequalities in IMR was sensitive to changes in the level of IMR.

Results

Descriptive results

Our study included 142 observations from 48 LMICs (an average of 3.0 observations per country). A list of countries included is in Appendix 1. The overall mean, overall standard deviation, between-country standard deviation, within-country standard deviation, and average within-country change per year for each variable are shown in Table 1. The mean IMR SII over the study period was 39.12, illustrating that the average absolute difference in the IMR between the richest and poorest quintiles was 39.12 deaths per 1000 live births. The IMR SII was falling at 2.022 per year on average, showing the absolute gap between the richest and poorest quintiles' IMR was narrowing over time. The mean IMR RII was 0.69 over the study period, meaning the IMR for the poorest quintile was on average 69% higher than for the richest quintile. The mean IMR RII was falling each year by 0.010 suggesting the relative differences in IMR were falling over time. Total government expenditure on average comprised 12.43% of a country's GDP and was increasing each year by 0.086%.

<Table 1 here>

Total government expenditure and inequalities in IMR

The results from the fixed-effects longitudinal regressions of the SII and RII of IMR on total government expenditure are shown in Table 2 and 3, including the sequential addition of covariates in models 1 to 5. In fully adjusted multivariate models, total government expenditure remains consistently and significantly associated with lower absolute (SII) and relative (RII) inequalities in the IMR, even when controlling for linear time trends, democracy, GDP per capita, and OOP and non-OOP private health expenditure. For each percentage increase in total government expenditure (as a per cent of GDP), the SII of IMR decreased by -2.468 (95% CIs: -4.190 to -0.746) and the RII decreased by -0.026 (95% CIs: -0.048 to -0.004). Apart from the time trends, all other covariates were non-significant except for democracy, which was significantly associated with reductions in RII, but not SII.

<Table 2 and 3 here>

Total government expenditure and quintile-specific IMR

To understand better the relationship between total government expenditure and reductions in inequalities in IMR, associations between IMR in each wealth quintile and total government expenditure were explored. Figure 2 shows the point estimates and confidence intervals for the coefficients for total government expenditure from the quintile-specific multivariate regression models on IMR. The relationship between total government expenditure and IMR appears to follow a social gradient, where the IMR falls the most in the poorest quintile. Full multivariate regression results are shown in Appendix 2. For the poorest quintile, a one-percentage point increase in total government expenditure was associated with a reduction in IMR of -2.020 (95% CIs: -3.835 to -0.187). The relationship between IMR and total government expenditure was non-significant in wealth quintiles 4 and 5 (the richest) suggesting the reductions in inequalities in IMR were driven mainly by reductions in IMR in the poorest quintiles.

<Figure 2 here>

Stratification by level of democracy

Because Polity IV was strongly bimodal, we divided our sample into two groups, using the median of the *Polity IV* democracy indicator as the cut-off. Respectively there were 24 countries in the lower democracy group and 24 countries in the higher democracy group. The results from multivariate regression models for both the SII and RII of IMR for both groups of countries are shown in Table 4a. Whilst there was no significant relationship between total government expenditure and inequalities in IMR in countries with lower levels of democracy, in countries with higher levels of democracy increased total government expenditure was associated with lower absolute inequalities in IMR (SII). During sensitivity analysis, very similar results were found when stratifying the countries by use of proportional representation (see Table 4b).

<Table 4a here>

<Table 4b here>

Inequalities in IMR and disaggregated government expenditure

This component of the study examines the relationship between inequalities in IMR and disaggregated government expenditure. As noted in the conceptual framework, total government expenditure might impact on health inequalities through government expenditure on health or government expenditure on non-health areas, or government redistribution effort. This was explored by repeating our regression models with disaggregated government expenditure.

Table 5 shows the results from multivariate regression models with total government expenditure (the same model as the first part of the analysis) and with total government expenditure divided into expenditure on health and non-health areas. In disaggregated models (models 2 and 4 in Table 5), there was no significant association between government expenditure on health and both the SII and RII of IMR, whereas government expenditure on non-health areas was significantly associated with reductions in both the SII and RII of IMR. Further disaggregation of total government expenditure was undertaken, although due to missing data the number of countries available for analysis was lower (Table 6). Total government expenditure was disaggregated into expenditure on health, education, and all non-health/non-education areas (models 1 and 2 in Table 6), and further into expenditure on the military and all non-health/non-education/non-military areas (models 3 and 4 in Table 6). In all models, government expenditure on health, education, and the military were not associated with inequalities in IMR. Government expenditure on non-health/non-education and also non-health/non-education/non-military areas were significantly associated with reductions in the SII of IMR. Respectively, the coefficients for these associations were - 5.493 (CI: -10.510 to -0.480) and -5.582 (CIs -10.230 to -0.931). There were no significant associations between these areas of government expenditures and the RII of IMR in these models. It is not possible to infer whether reduced sample-size (and statistical power), the nature of the sub-sample of countries, or the underlying relationships with government expenditure explain either the non-significance of the RII of IMR or the greater reductions in the SII found compared to the models earlier in the analysis. This is the limit of how much government expenditure can be broken down in our data.

<Table 5 and 6 here >

Association between government redistribution efforts and IMR inequalities

The regression models including total government expenditure were repeated with the addition of a government redistribution effort variable (Table 7, models 2 and 4). Missing data reduced the number of available observations, so for comparability, the main regressions with total government expenditure but without redistribution efforts were repeated on the sub-sample (models 1 and 3 in Table 7). Similar relationships between total government expenditure and the reductions in the SII in IMR were observed both with and without government redistribution efforts, and these were also comparable to the results on the whole sample of countries. Regarding the RII, there was no significant relationship between total government expenditure in either model suggesting the reduced number of observations limited statistical power. Government redistribution efforts were not significant associated with SII or RII. As a sensitivity analysis, when government redistribution effort was replaced with income inequality before government redistribution (market GINI), the results remained essentially unchanged and market GINI was not significantly associated with SII or RII (see Appendix 3).

<Table 7 here>

Sensitivity analyses

The main results were robust to the removal of outliers, observations with high leverage and the use of year dummies rather than linear time trends. Total government expenditure also remained significantly and negatively associated with inequalities in IMR in all 32 alternative model specifications in Stata module *mrobust* (Young and Holsteen, 2015).

Intermediate factors between the relationship of government expenditure and IMR inequalities were sequentially included in the regression model to test whether total government expenditure remained significant. Although a sub-sample of countries was used (due to missing data), the relationship between total government expenditure and inequalities in IMR remained significant and with a similar coefficient after controlling for mean Water and Sanitation coverage, and inequalities in Fertility, Stunting and Health Service Coverage (see Appendix 4 for results). Finally, the addition of the absolute level of IMR to the models did not significantly change the results (see Appendix 5).

Discussion

Key findings

Total government expenditure was consistently associated with lower absolute (SII) and relative (RII) inequalities in IMRs, even when controlling for country fixed effects, linear time trends, democracy, GDP per capita, OOP and non-OOP private health expenditure. For each percentage point that total government expenditure increased (as a % of GDP), the SII of IMR decreased by -2.468 (95% CIs: -4.190 to -0.746) and the RII of IMR decreased by -0.026 (95% CIs: -0.048 to -0.004). This means that for each percentage point increase in government spending as a proportion of GDP, the difference in infant mortality rates between the richest and poorest quintile fell by 2.468, which is approximately 6.5% of the total difference.

Further examination of this relationship identified that it is mainly driven by reductions in the IMR in the poorest quintiles and appears to occur mostly in countries with higher levels of democracy (and those that use proportional representation). Disaggregation of government expenditure revealed that the relationship between total government expenditure and reduced inequalities in

IMR appears to be driven by expenditure on non-health rather than health areas. Furthermore, results from a sub-sample of countries shows that the relationship between lower inequalities and total government expenditures persisted when removing expenditure on health, education, and the military. No evidence was found that GDP per capita, government redistribution, government health expenditures or private health expenditures were associated with inequalities in IMR. Our results were robust to alternative model specifications and to the inclusion of intermediate factors in the models.

We originally hypothesised three factors that could influence inequalities in IMR: government health expenditure, government non-health expenditure, and government redistribution efforts. This was based on Houweling and Kunst's conceptual framework (2010). Our findings support the hypothesis that government non-health expenditure is most strongly associated with reducing infant health inequalities.

There are a range of potential mechanisms that could explain our findings. However, due to limited data availability, our study was not able to identify specific components of non-health government expenditure most strongly associated with lower inequalities in IMR. In the 69 observations with data available, our sub-analysis suggested that, even when removing health, education and military expenditure, government expenditure remains strongly and significantly associated with reducing inequalities in IMR. What remains in this section of government expenditure is not reported in the World Bank database.

It may include government expenditure that expands basic incomes through social protection programmes or employment, improves transport and infrastructure, or promotes a healthier environment. For example, recent evidence has found that social protection expenditures can improve health outcomes and reduce health inequalities (Ataguba et al., 2015; Khan et al., 2016; Stuckler et al., 2009; WHO, 2008). Further research, focusing on countries with more disaggregated government expenditure data, and particularly social protection data, is needed to explore this further.

The non-significance of health expenditures (both from the government and private sector) was found in all our models. This is consistent with the results of two recent cross-sectional ecological studies that also found no evidence that health expenditures were associated with inequalities in neonatal and child mortality inequalities (Kruk et al., 2011; McKinnon et al., 2016). There are multiple pathways through which health expenditure can improve infant mortality, but the extent to which distribution of funds and resources in the health system are "pro-poor" and reduce health inequalities is politically determined and cannot be assumed. Indeed, government health expenditure in high income countries is often noted to be pro-rich, as noted by Hart, who described it as the *inverse care law* (Hart, 1971; McLean et al., 2015).

We found that redistribution efforts by governments had no association with inequalities in IMR in LMICs. Whilst this result is surprising theoretically, empirical studies have often been unable to confirm the link between income inequalities and child health inequality, particularly in LMICs (Houweling and Kunst, 2010; Truesdale and Jencks, 2016). Indeed, in one cross-sectional, ecological study using DHS data in LMICs, McKinnon et al. (2016) were also unable to find an association between income inequality and inequalities in neonatal mortality rates. One explanation for this finding might be that the fixed effect methodology we employed estimates only *within*-country associations over time. The mean government redistribution value was 4.90 with a standard deviation of 2.31, but the mean within-country standard deviation was only 0.41 suggesting that, as expected, most of the variation in redistribution mechanisms is between countries – something that was not estimated in this analysis. Whilst we might conclude that changes in within-country redistributive efforts do not appear to affect IMR inequalities, we do not know about the effect between countries on average. Furthermore, we only looked for associations in changes in inequalities in IMR and redistributive efforts at the same point in time, and so, compared to government expenditures, there may be a greater period until the effects of redistributive efforts are felt.

Strengths and limitations

Fixed-effects longitudinal regression methods are robust methods for evaluating associations over time as time-invariant confounders can be controlled for and they permit elucidation of associations whilst controlling for time trends. Between-country variation is removed however, and so understanding of potential differences between countries in the terms of the explanatory variables is lost. This was considered necessary to avoid the assumptions of random-effects specifications. Country-level data points are used in this analysis and so an ecological bias may be present. It is therefore not possible to make individual inference based on this analysis. Furthermore, the study design does not enable causal inference and the relationships identified must be considered as associations.

The use of both Slope and Relative Indices of Inequality, which in this study generally went in the same direction, enabled us to assess the impact on both absolute and relative inequalities. This measure makes use of data from across five wealth quintiles, and so is a better summary description of overall inequality. Because we generated the SII and RII from quintile-specific IMRs, there is still likely to be considerable heterogeneity within each wealth quintile. This study was thus unable to assess any associations or factors that changed within each quintile.

Data limitations are inevitable when in LMICs, however the DHS do produce reliable and high-quality datasets. Standardised methodology enables comparison between the 48 countries and over time periods in addition to the creation of measures of health inequalities in IMR. Whilst it is important to acknowledge limitations may exist in terms of sampling strategy and response bias, DHS datasets are very valuable for conducting research in data-limited LMICs. There were a limited number of DHS surveys carried out to date that could be used in the analysis. This allowed us to include 142 observations, which, although sufficient when examining total government expenditure, was problematic for any further sub-analysis. For example, it was not possible to examine differences by regions of the world or by country development. Lack of data on inequalities in access to water and sanitation also prevented us from adequately exploring this promising intermediate variable. Missing data from countries on income inequality, and disaggregated government expenditure reduced the sample size substantially and compromised statistical power. Our wealth index, while widely used in the context of low-and-middle-income countries, is not a perfect measure of wealth, and different components of the index may be differently valued across countries. Finally, there was limited data on further disaggregated government expenditure, and particularly on social protection expenditures, which prevented further elucidation of potential mechanisms of action.

Conclusion

This is the first study to the authors' knowledge to examine total government expenditure and health inequalities in IMR in LMICs. There appears to be relationship between non-health government expenditure, potentially mediated through the wider social determinants of health, which needs to be further investigated. Further studies are warranted to determine the exact components of government expenditure that impart impact and the mechanisms of action. It is further necessary to understand the reasons as to why health inequalities seem resistant to increases in government health expenditure and mechanisms to redistribute income.

Theoretical considerations underpin much of the current global agenda for improving health and reducing inequalities. This research identifies that one widely believed idea, that spending more money on health will improve health inequalities, is not necessarily true. Instead, our results suggest that increasing other areas of Government expenditure might be more important, and future research should aim to disentangle which areas of public policy might be more critical to reduce infant mortality among the poor. Expanding the debate within the global development arena and with donor agencies, and furthering our understanding of the relationships between governments and inequalities is vital to prioritise policies and interventions to reduce health inequalities.

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Table 1: Summary of means, overall standard deviation, between country standard deviation, mean within-country standard deviations and mean within-country trends for variables

Variable	Overall Mean	Overall SD	Between - country SD	Within-country SD	Mean annual within-country change	n (countries)	N (Obs)
IMR SII (Slope Index of Inequality)	*39.12*	*23.67*	*18.65*	*15.53*	*-2.022****	*48*	*142*
IMR RII (Relative Index of Inequality)	*0.69*	*0.40*	*0.34*	*0.19*	*-0.010***	*48*	*142*
Total government expenditure (% of GDP)	*12.43*	*5.33*	*5.57*	*1.43*	*0.086***	*48*	*142*
Gov health expenditure (% of GDP)	*2.31*	*1.19*	*1.10*	*0.49*	*0.044****	*48*	*142*
Gov non-health expenditure (% of GDP)	*10.12*	*4.62*	*4.84*	*1.36*	*0.041*	*48*	*142*
Gov expenditure minus health education & military (% GDP)	*4.48*	*2.76*	*3.33*	*0.80*	*0.003*	*39*	*82*
Redistribution (Gini market - Gini net)	*4.90*	*2.31*	*2.24*	*0.41*	*0.015*	*44*	*110*
Log GDP per capita (2011 USD adjusted for PPP)	*7.81*	*0.81*	*0.78*	*0.22*	*0.031****	*48*	*142*
Democracy (Polity IV)	*3.20*	*4.88*	*4.38*	*2.40*	*0.200***	*48*	*142*
Private non-OOP health expenditure (% of GDP)	*0.68*	*0.81*	*0.78*	*0.35*	*0.033****	*48*	*142*
Private OOP health expenditure (% of GDP)	*2.31*	*1.17*	*1.23*	*0.39*	*-0.014*	*48*	*142*
Improved water source (% of population)	*73.61*	*15.77*	*15.23*	*4.62*	*0.764****	*48*	*142*
Improved sanitation facilities (% of population)	*41.51*	*26.86*	*26.20*	*3.55*	*0.600****	*48*	*142*
Fertility Slope Index of Inequality	*3.51*	*1.49*	*1.39*	*0.64*	*-0.001*	*47*	*130*
Stunting Slope Index of Inequality	*24.10*	*12.55*	*11.69*	*4.57*	*-0.124*	*45*	*129*
Health Services Slope Index of Inequality	*30.50*	*13.67*	*12.18*	*6.11*	*-0.785****	*45*	*131*

*Note: Time trends were estimated with univariate fixed-effects regression of each variable with time. Stars represent trend significance: * p<0.05 ** p<0.01 *** p<0.001; SD – Standard deviation; SII* - IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table 2: Results from fixed-effects longitudinal regressions of the Slope Index of Inequality on total government expenditure (for 48 countries from 1993-2013)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	IMR SII	*IMR SII*	*IMR SII*	*IMR SII*	*IMR SII*
Total government expenditure [1]	*-4.371****	*-2.628***	*-2.549***	*-2.577***	*-2.468***
	(-4.58)	*(-3.04)*	*(-3.02)*	*(-3.11)*	*(-2.88)*
Year		*-1.798****	*-1.604****	*-1.486****	*-1.350***
		(-5.97)	*(-3.83)*	*(-3.65)*	*(-3.01)*
GDP per capita (Log) [2]			*-6.413*	*-7.361*	*-7.881*
			(-0.74)	*(-0.84)*	*(-0.84)*
Democracy (Polity IV)				*-0.430*	*-0.519*
				(-0.90)	*(-1.05)*
Private non-OOP health expenditure [1]					*-3.698*
					(-0.76)
Private OOP health expenditure [1]					*-0.698*
					(-0.18)
Constant	*93.43****	*3674.5****	*3335.6****	*3107.8****	*2843.5***
	(7.87)	*(6.13)*	*(4.22)*	*(4.06)*	*(3.36)*
N (Observations)	*142*	*142*	*142*	*142*	*142*

Notes: *t statistics in parentheses* * $p<0.05$ ** $p<0.01$ *** $p<0.001$ [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table 3: Results from fixed-effects longitudinal regressions of the Relative Index of Inequality on total government expenditure (for 48 countries from 1993-2013)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	IMR RII	*IMR RII*	*IMR RII*	*IMR RII*	*IMR RII*
Total government expenditure [1]	*-0.033***	*-0.026**	*-0.025**	*-0.026**	*-0.026**
	(-3.19)	*(-2.38)*	*(-2.37)*	*(-2.50)*	*(-2.36)*
Year		*-0.007*	*-0.006*	*-0.003*	*-0.002*
		(-2.00)	*(-1.14)*	*(-0.55)*	*(-0.45)*
GDP per capita (Log) [2]			*-0.054*	*-0.079*	*-0.088*
			(-0.50)	*(-0.76)*	*(-0.82)*
Democracy (Polity IV)				*-0.012**	*-0.012**
				(-2.02)	*(-2.03)*
Private non-OOP health expenditure [1]					*-0.009*
					(-0.16)
Private OOP health expenditure [1]					*-0.031*
					(-0.61)
Constant	*1.098****	*15.860**	*13.030*	*6.935*	*6.636*
	(8.54)	*(2.15)*	*(1.36)*	*(0.78)*	*(0.65)*
Observations	*142*	*142*	*142*	*142*	*142*

Notes: *t statistics in parentheses* * $p<0.05$ ** $p<0.01$ *** $p<0.001$ [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table 4a: Results from fixed-effects longitudinal regressions of the Slope and Relative Index of Inequality of IMR on total government expenditure for 24 less democratic and 24 more democratic countries (1993-2013)

	Less Democratic Countries (Lower Polity IV)		*More Democratic Countries (Higher Polity IV)*	
	(1)	*(2)*	*(3)*	*(4)*
	IMR SII	*IMR RII*	*IMR SII*	*IMR RII*
Total government expenditure [1]	*-1.851*	*-0.0259*	*-3.102***	*-0.0247*
	(-1.14)	*(-1.30)*	*(-3.60)*	*(-1.93)*
Year	*-1.302*	*-0.00624*	*-1.666***	*-0.00693*
	(-1.70)	*(-0.60)*	*(-3.34)*	*(-1.15)*
Log GDP per capita [2]	*-9.889*	*0.0200*	*-6.554*	*-0.178*
	(-0.73)	*(0.12)*	*(-0.53)*	*(-1.19)*
Private non-OOP health expenditure [1]	*5.775*	*0.116*	*-6.349*	*-0.0309*
	(0.60)	*(0.86)*	*(-1.47)*	*(-0.69)*
Private OOP health expenditure [1]	*-2.525*	*-0.0608*	*-1.094*	*-0.0338*
	(-0.40)	*(-0.75)*	*(-0.34)*	*(-0.59)*
Constant	*2748.1*	*13.32*	*3479.4***	*16.50*
	(1.89)	*(0.68)*	*(3.75)*	*(1.46)*
Observations	*70*	*70*	*72*	*72*

Notes: *t statistics in parentheses,* * $p<0.05$ ** $p<0.01$ *** $p<0.001$. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table 4b: Results from fixed-effects longitudinal regressions of the Slope and Relative Index of Inequality of IMR on total government expenditure for 24 countries without proportional representation and 26 countries with proportional representation (1993-2013)

	Non-Proportional Representation countries		***Proportional Representation countries***	
	(1)	*(2)*	*(3)*	*(4)*
	IMR SII	*IMR RII*	*IMR SII*	*IMR RII*
Total government expenditure [1]	*-1.062*	*-0.0116*	*-3.338***	*-0.0269*
	(-0.72)	*(-0.63)*	*(-3.14)*	*(-1.69)*
Year	*-1.374*	*-0.00980*	*-1.929****	*-0.00973*
	(-1.71)	*(-0.96)*	*(-3.94)*	*(-1.72)*
Log GDP per capita [2]	*-13.73*	*-0.0344*	*-2.799*	*-0.122*
	(-0.91)	*(-0.19)*	*(-0.25)*	*(-0.89)*
Private non-OOP health expenditure [1]	*-6.206*	*-0.0534*	*0.164*	*0.0958*
	(-0.89)	*(-0.60)*	*(0.03)*	*(1.14)*
Private OOP health expenditure [1]	*1.484*	*0.0239*	*-3.913*	*-0.0695*
	(0.20)	*(0.34)*	*(-1.01)*	*(-0.97)*
Constant	*2910.2*	*20.54*	*3981.2****	*21.74*
	(1.90)	*(1.05)*	*(4.31)*	*(2.01)*
Observations	*61*	*61*	*73*	*73*

Notes: *t statistics in parentheses,* * p<0.05 ** p<0.01 *** p<0.001. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table 5 – Results from fixed-effects longitudinal regressions of the Slope and Relative Index of Inequality of IMR on total and disaggregated government expenditure (for 48 countries from 1993-2013)

	(1)	*(2)*	*(3)*	*(4)*
	IMR SII	*IMR SII*	*IMR RII*	*IMR RII*
Total government expenditure [1]	*-2.468***		*-0.0257**	
	(-2.88)		*(-2.36)*	
Gov non-health expenditure [1]		*-3.030****		*-0.0311***
		(-3.58)		*(-2.98)*
Gov health expenditure [1]		*4.084*		*0.0378*
		(1.18)		*(0.88)*
Year	*-1.350***	*-1.641***	*-0.00241*	*-0.00522*
	(-3.01)	*(-3.42)*	*(-0.45)*	*(-0.88)*
Log GDP per capita [2]	*-7.881*	*-7.717*	*-0.0877*	*-0.0861*
	(-0.84)	*(-0.87)*	*(-0.82)*	*(-0.84)*
Democracy (Polity IV)	*-0.519*	*-0.580*	*-0.0120**	*-0.0126**
	(-1.05)	*(-1.17)*	*(-2.03)*	*(-2.06)*
Private non-OOP health expenditure [1]	*-3.698*	*-2.464*	*-0.00932*	*0.00264*
	(-0.76)	*(-0.51)*	*(-0.16)*	*(0.05)*
Private OOP health expenditure [1]	*-0.698*	*-0.0504*	*-0.0307*	*-0.0244*
	(-0.18)	*(-0.01)*	*(-0.61)*	*(-0.50)*
Constant	*2843.5***	*3412.7****	*6.636*	*12.15*
	(3.36)	*(3.76)*	*(0.65)*	*(1.07)*
Observations	*142*	*142*	*142*	*142*

Notes: *t statistics in parentheses,* * $p<0.05$ ** $p<0.01$ *** $p<0.001$. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table 6: Results from fixed-effects longitudinal regressions of the Slope and Relative Index of Inequality of IMR on non-health/non-education government expenditure and on government expenditure net of health, education, & military (in 26 countries from 1993-2013)

	(1)	*(2)*	*(3)*	*(4)*
	IMR SII	*IMR RII*	*IMR SII*	*IMR RII*
Gov non-health non-education expenditure 1	*-5.493**	*-0.0594*		
	(-2.26)	*(-1.83)*		
Gov expenditure net of health, education, & military [1]			*-5.582**	*-0.0594*
			(-2.47)	*(-1.81)*
Gov education expenditure [1]	*3.086*	*0.0186*	*3.597*	*0.0185*
	(0.80)	*(0.42)*	*(1.04)*	*(0.41)*
Gov health expenditure [1]	*-2.224*	*-0.0483*	*-2.374*	*-0.0483*
	(-0.51)	*(-0.81)*	*(-0.53)*	*(-0.81)*
Military expenditure [1]			*4.852*	*-0.0617*
			(0.91)	*(-0.60)*
Year	*-2.192**	*-0.00697*	*-2.218***	*-0.00696*
	(-2.62)	*(-0.71)*	*(-3.31)*	*(-0.70)*
Log GDP per capita [2]	*0.132*	*-0.0874*	*5.827*	*-0.0886*
	(0.01)	*(-0.45)*	*(0.45)*	*(-0.41)*
Democracy (Polity IV)	*-0.145*	*-0.00373*	*0.136*	*-0.00379*
	(-0.25)	*(-0.46)*	*(0.22)*	*(-0.44)*
Private non-OOP health expenditure [1]	*-1.889*	*-0.0135*	*-1.398*	*-0.0136*
	(-0.33)	*(-0.20)*	*(-0.26)*	*(-0.20)*
Private OOP health expenditure [1]	*0.936*	*0.0348*	*2.670*	*0.0344*
	(0.20)	*(0.64)*	*(0.57)*	*(0.53)*
Constant	*4461.0***	*15.82*	*4442.5***	*15.82*
	(2.83)	*(0.86)*	*(3.51)*	*(0.85)*
Observations	*69*	*69*	*69*	*69*

Notes: t statistics in parentheses, * $p<0.05$ ** $p<0.01$ *** $p<0.001$. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table 7: Results from fixed-effects longitudinal regressions of the Slope and Relative Index of Inequality of IMR on total government expenditure and government redistribution efforts (36 countries from 1993-2013)

	(1)	*(2)*	*(3)*	*(4)*
	IMR SII	*IMR SII*	*IMR RII*	*IMR RII*
Total government expenditure [1]	*-2.561**	*-2.620**	*-0.0248*	*-0.0257*
	(-2.44)	*(-2.47)*	*(-1.60)*	*(-1.59)*
Year	*-1.588***	*-1.623***	*-0.00610*	*-0.00660*
	(-2.75)	*(-2.84)*	*(-0.94)*	*(-1.06)*
Log GDP per capita [2]	*-8.339*	*-7.939*	*-0.165*	*-0.159*
	(-0.71)	*(-0.67)*	*(-1.23)*	*(-1.17)*
Democracy (Polity IV)	*-0.477*	*-0.422*	*-0.00841*	*-0.00762*
	(-1.06)	*(-0.90)*	*(-1.14)*	*(-0.95)*
Private non-OOP health expenditure [1]	*6.277*	*5.891*	*0.0824*	*0.0769*
	(1.20)	*(1.04)*	*(1.11)*	*(0.93)*
Private OOP health expenditure [1]	*-1.562*	*-2.088*	*-0.0186*	*-0.0261*
	(-0.38)	*(-0.47)*	*(-0.40)*	*(-0.48)*
Government redistribution efforts [3]		*1.474*		*0.0211*
		(0.35)		*(0.25)*
Constant	*3319.0***	*3379.9***	*14.60*	*15.47*
	(3.05)	*(3.15)*	*(1.20)*	*(1.33)*
Observations	*102*	*102*	*102*	*102*

Notes: t statistics in parentheses. * $p<0.05$ ** $p<0.01$ *** $p<0.001$ [1] (% of GDP); [2] (2011 USD adjusted for PPP); [3] (Gini market minus Gini net); IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Figure 1: Conceptual framework, based on (Houweling and Kunst, 2010; Mosley and Chen, 1984)

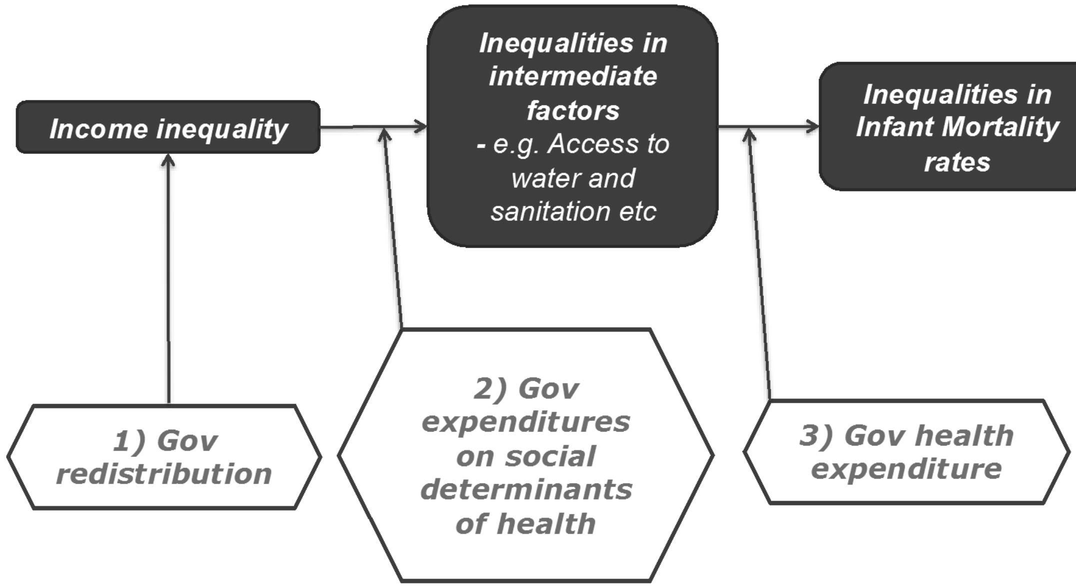
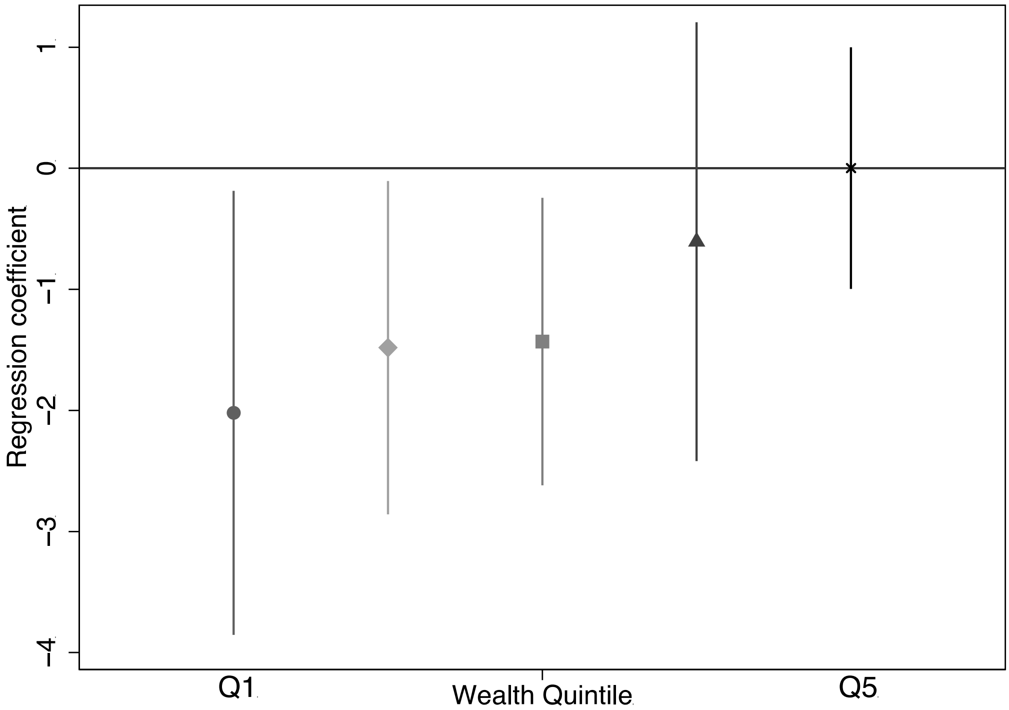


Figure 2: Regression coefficients of total government expenditure from multivariate longitudinal regressions of quintile-specific IMR on total government expenditure for each wealth quintile (for 48 countries from 1993-2013)



Notes: The reported coefficients were obtained from multivariate fixed-effects longitudinal regressions of the quintile-specific IMR on total government expenditure for each wealth quintiles. In addition to total government expenditure as a percentage of GDP (coefficients shown in figure), models were controlled for GDP per capita (Log), Democracy, Private non-OOP health expenditure as a percentage of GDP, Private OOP health expenditure as a percentage of GDP, country-level fixed-effects, and a linear time trend. Figure shows point estimates and 95% confidence intervals.

Appendix 1: 48 Countries included in main panels

Armenia
Bangladesh
Benin
Bolivia (Plurinational State of)
Burkina Faso
Cambodia
Cameroon
Chad
Colombia
Comoros
Congo
Cote d'Ivoire
Democratic Republic of the Congo
Dominican Republic
Egypt
Gabon
Ghana
Guatemala
Guinea
Haiti
Honduras
India
Indonesia
Jordan
Kazakhstan
Kenya
Lesotho
Liberia
Madagascar
Malawi
Mali
Mozambique
Namibia
Nepal
Nicaragua
Niger
Nigeria
Pakistan
Peru
Philippines
Rwanda
Senegal
Sierra Leone
Turkey
Uganda
United Republic of Tanzania
Viet Nam
Zimbabwe

Appendix 2: Detailed results from fixed-effects longitudinal regressions of each wealth quintile's IMR on total health expenditure for 48 countries (1993-2013)

	(1)	(2)	(3)	(4)	(5)
	WQ1 IMR	**WQ2 IMR**	**WQ3 IMR**	**WQ4 IMR**	**WQ5 IMR**
Total government expenditure[1]	-2.020*	-1.482*	-1.431*	-0.606	0.00188
	(-2.22)	(-2.17)	(-2.43)	(-0.67)	(0.00)
Year	-2.473***	-2.788***	-2.329***	-2.304***	-1.376***
	(-5.70)	(-7.03)	(-6.89)	(-5.98)	(-5.74)
Log GDP per capita [2]	-2.162	2.485	1.008	5.107	4.469
	(-0.29)	(0.34)	(0.19)	(0.95)	(1.13)
Democracy (Polity IV)	0.327	0.617	0.773	0.598	0.864*
	(0.59)	(1.12)	(1.33)	(1.09)	(2.28)
Private non-OOP health expenditure[1]	-6.472	-2.544	-2.642	-4.151	-1.827
	(-1.25)	(-0.52)	(-0.61)	(-0.79)	(-0.70)
Private OOP health expenditure [1]	0.160	-0.248	-0.108	2.572	-0.543
	(0.05)	(-0.08)	(-0.04)	(0.94)	(-0.32)
Constant	5078.5***	5658.3***	4744.2***	4640.1***	2767.9***
	(6.13)	(7.50)	(7.37)	(6.25)	(6.05)
Observations	142	142	142	141	141

Notes: *t statistics in parentheses,* * $p<0.05$ ** $p<0.01$ *** $p<0.001$. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; OOP – Out of pocket; GDP –Gross Domestic product.

Appendix 3 – addition of market GINI

Table A3 Government redistribution models (1) and (3), with market Gini added in in (2) and (4)

		With Gini_market		*With Gini_market*
	(1)	*(2)*	*(3)*	*(4)*
	IMR SII	*IMR SII*	*IMR RII*	*IMR RII*
Total government expenditure (% of GDP)	*-2.561**	*-2.607**	*-0.0248*	*-0.0284*
	(-2.44)	*(-2.60)*	*(-1.60)*	*(-1.79)*
Year	*-1.588***	*-1.627***	*-0.00610*	*-0.00570*
	(-2.75)	*(-2.87)*	*(-0.94)*	*(-0.91)*
Log GDP per capita (2011 USD adjusted for PPP)	*-8.339*	*-8.001*	*-0.165*	*-0.146*
	(-0.71)	*(-0.67)*	*(-1.23)*	*(-1.10)*
Democracy (Polity IV)	*-0.477*	*-0.429*	*-0.00841*	*-0.00600*
	(-1.06)	*(-0.94)*	*(-1.14)*	*(-0.75)*
Private non-OOP health expenditure (% of GDP)	*6.277*	*5.915*	*0.0824*	*0.0718*
	(1.20)	*(1.05)*	*(1.11)*	*(0.86)*
Private OOP health expenditure (% of GDP)	*-1.562*	*-2.106*	*-0.0186*	*-0.0222*
	(-0.38)	*(-0.48)*	*(-0.40)*	*(-0.38)*
gini_market		*-0.0530*		*0.0113*
		(-0.07)		*(0.84)*
Gov Redistribution (Gini market - Gini net)		*1.629*		*-0.0120*
		(0.31)		*(-0.11)*
Constant	*3319.0***	*3390.5***	*14.60*	*13.21*
	(3.05)	*(3.20)*	*(1.20)*	*(1.12)*
Observations	*102*	*102*	*102*	*102*

Notes: *t statistics in parentheses,* * p<0.05 ** p<0.01 *** p<0.001. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Appendix 4: Additional analysis of intermediate variables

Tables A4.1: Adding Water and Sanitation covariates to main model for 48 countries between 1993-2013 (models 1 and 3 show main SII and RII models, 2 and 4 include additional covariates)

	(1)	(2)	(3)	(4)
	IMR SII	IMR SII	IMR RII	IMR RII
Total government expenditure [1]	-2.468**	-2.472**	-0.0257*	-0.0253*
	(-2.88)	(-2.78)	(-2.36)	(-2.34)
Year	-1.350**	-1.894**	-0.00241	-0.0172
	(-3.01)	(-2.76)	(-0.45)	(-2.00)
Log GDP per capita [2]	-7.881	-7.363	-0.0877	-0.0784
	(-0.84)	(-0.80)	(-0.82)	(-0.77)
Democracy (Polity IV)	-0.519	-0.479	-0.0120*	-0.0114
	(-1.05)	(-0.93)	(-2.03)	(-1.99)
Private non-OOP health expenditure [1]	-3.698	-4.641	-0.00932	-0.0305
	(-0.76)	(-1.05)	(-0.16)	(-0.66)
Private OOP health expenditure [1]	-0.698	-0.926	-0.0307	-0.0399
	(-0.18)	(-0.23)	(-0.61)	(-0.78)
Improved water source (% of population)		0.408		0.00856
		(0.81)		(1.39)
Improved sanitation facilities (% of population)		0.393		0.0140
		(0.63)		(1.86)
Constant	2843.5**	3883.8**	6.636	35.05*
	(3.36)	(2.98)	(0.65)	(2.14)
Observations	142	142	142	142

Notes: *t statistics in parentheses,* * $p<0.05$ ** $p<0.01$ *** $p<0.001$. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table A4.2: Adding Slope Index of Inequality covariates for fertility, stunting and health services to main SII model. Models 1, 3 and 5 show main SII model, 2, 4 and 6 include additional covariates.

	(1)	(2)	(3)	(4)	(5)	(6)
	IMR SII	IMR SII	IMR SII	IMR SII	IMR SII	IMR SII
Total government expenditure [1]	-2.423*	-2.804**	-2.530**	-2.478**	-2.206*	-1.848*
	(-2.61)	(-2.82)	(-2.75)	(-2.70)	(-2.53)	(-2.08)
Year	-1.517**	-1.377**	-1.339**	-1.254*	-1.598**	-1.178*
	(-3.09)	(-2.70)	(-2.76)	(-2.61)	(-3.45)	(-2.15)
Log GDP per capita [2]	-6.647	-5.925	-9.971	-10.25	-4.733	-5.416
	(-0.69)	(-0.60)	(-1.02)	(-1.07)	(-0.48)	(-0.51)
Democracy (Polity IV)	-0.437	-0.545	-0.961	-1.004	-0.487	-0.368
	(-0.70)	(-0.91)	(-1.60)	(-1.69)	(-0.97)	(-0.73)
Private non-OOP health expenditure [1]	-3.535	-6.300	-3.520	-4.226	-3.863	-4.827
	(-0.69)	(-1.29)	(-0.72)	(-0.90)	(-0.78)	(-1.10)
Private OOP health expenditure [1]	-0.00779	-0.929	-0.975	-0.495	-0.674	-0.744
	(-0.00)	(-0.25)	(-0.22)	(-0.11)	(-0.15)	(-0.19)
Fertility Slope Index of Inequality		4.409				
		(1.43)				
Stunting Slope Index of Inequality				0.335		
				(1.04)		
Health Services Slope Index of Inequality						0.536
						(1.30)
Constant	3166.3**	2874.2**	2839.7**	2661.9**	3312.1***	2456.3*
	(3.39)	(2.96)	(3.09)	(2.93)	(3.79)	(2.31)
Observations	128	128	128	128	131	131

Notes: *t statistics in parentheses,* * p<0.05 ** p<0.01 *** p<0.001. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; SII - Slope index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Table A4.3: Adding Slope Index of Inequality covariates for fertility, stunting and health services to main RII model. Models 1, 3 and 5 show main RII model, 2, 4 and 6 include additional covariates.

	(1)	(2)	(3)	(4)	(5)	(6)
	IMR RII	IMR RII	IMR RII	IMR RII	IMR RII	IMR RII
Total government expenditure [1]	-0.0256*	-0.0298*	-0.0245*	-0.0236	-0.0207	-0.0175
	(-2.22)	(-2.43)	(-2.12)	(-1.99)	(-1.95)	(-1.67)
Year	-0.00540	-0.00389	-0.00277	-0.00129	-0.00676	-0.00298
	(-0.97)	(-0.66)	(-0.48)	(-0.23)	(-1.29)	(-0.42)
Log GDP per capita [2]	-0.0488	-0.0410	-0.121	-0.125	-0.0153	-0.0215
	(-0.44)	(-0.38)	(-1.09)	(-1.17)	(-0.14)	(-0.19)
Democracy (Polity IV)	-0.0114	-0.0125	-0.0158*	-0.0166*	-0.0101	-0.00904
	(-1.53)	(-1.64)	(-2.07)	(-2.31)	(-1.66)	(-1.35)
Private non-OOP health expenditure [1]	-0.0167	-0.0465	-0.00349	-0.0157	-0.0138	-0.0225
	(-0.29)	(-0.81)	(-0.06)	(-0.28)	(-0.24)	(-0.40)
Private OOP health expenditure [1]	-0.0249	-0.0348	-0.0396	-0.0313	-0.0473	-0.0479
	(-0.42)	(-0.64)	(-0.71)	(-0.58)	(-0.86)	(-0.92)
Fertility Slope Index of Inequality		0.0475				
		(1.31)				
Stunting Slope Index of Inequality				0.00582		
				(1.01)		
Health Services Slope Index of Inequality						0.00484
						(0.92)
Constant	12.30	9.152	7.598	4.513	14.77	7.052
	(1.16)	(0.81)	(0.69)	(0.43)	(1.49)	(0.51)
Observations	128	128	128	128	131	131

Notes: *t statistics in parentheses,* * p<0.05 ** p<0.01 *** p<0.001. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.

Appendix 5 – Addition of IMR to main models

Table A4.1: Main regressions (1) and (3), with the addition of IMR covariates in (2) and (4).

		With IMR		*With IMR*
	(1)	*(2)*	*(3)*	*(4)*
	IMR SII	*IMR SII*	*IMR RII*	*IMR RII*
Total government expenditure (% of GDP)	*-2.468***	*-1.975**	*-0.0257**	*-0.0262**
	(-2.88)	*(-2.39)*	*(-2.36)*	*(-2.33)*
Year	*-1.350***	*-0.349*	*-0.00241*	*-0.00342*
	(-3.01)	*(-0.83)*	*(-0.45)*	*(-0.46)*
Log GDP per capita (2011 USD adjusted for PPP)	*-7.881*	*-8.874*	*-0.0877*	*-0.0867*
	(-0.84)	*(-1.07)*	*(-0.82)*	*(-0.81)*
Democracy (Polity IV)	*-0.519*	*-0.804*	*-0.0120**	*-0.0117*
	(-1.05)	*(-1.75)*	*(-2.03)*	*(-1.91)*
Private non-OOP health expenditure (% of GDP)	*-3.698*	*-2.211*	*-0.00932*	*-0.0108*
	(-0.76)	*(-0.48)*	*(-0.16)*	*(-0.19)*
Private OOP health expenditure (% of GDP)	*-0.698*	*-0.864*	*-0.0307*	*-0.0305*
	(-0.18)	*(-0.24)*	*(-0.61)*	*(-0.60)*
Infant Mortality Rate		*0.442***		*-0.000446*
		(3.23)		*(-0.21)*
Constant	*2843.5***	*810.4*	*6.636*	*8.689*
	(3.36)	*(1.00)*	*(0.65)*	*(0.60)*
Observations	*142*	*142*	*142*	*142*

Notes: *t statistics in parentheses,* * p<0.05 ** p<0.01 *** p<0.001. [1] (% of GDP); [2] (2011 USD adjusted for PPP); IMR – infant mortality rate; RII- Relative index of inequality; OOP – Out of pocket; GDP –Gross Domestic product.